Michael Wright
University of Hawaii at Manoa
M.Ed. Learning Design and Technology

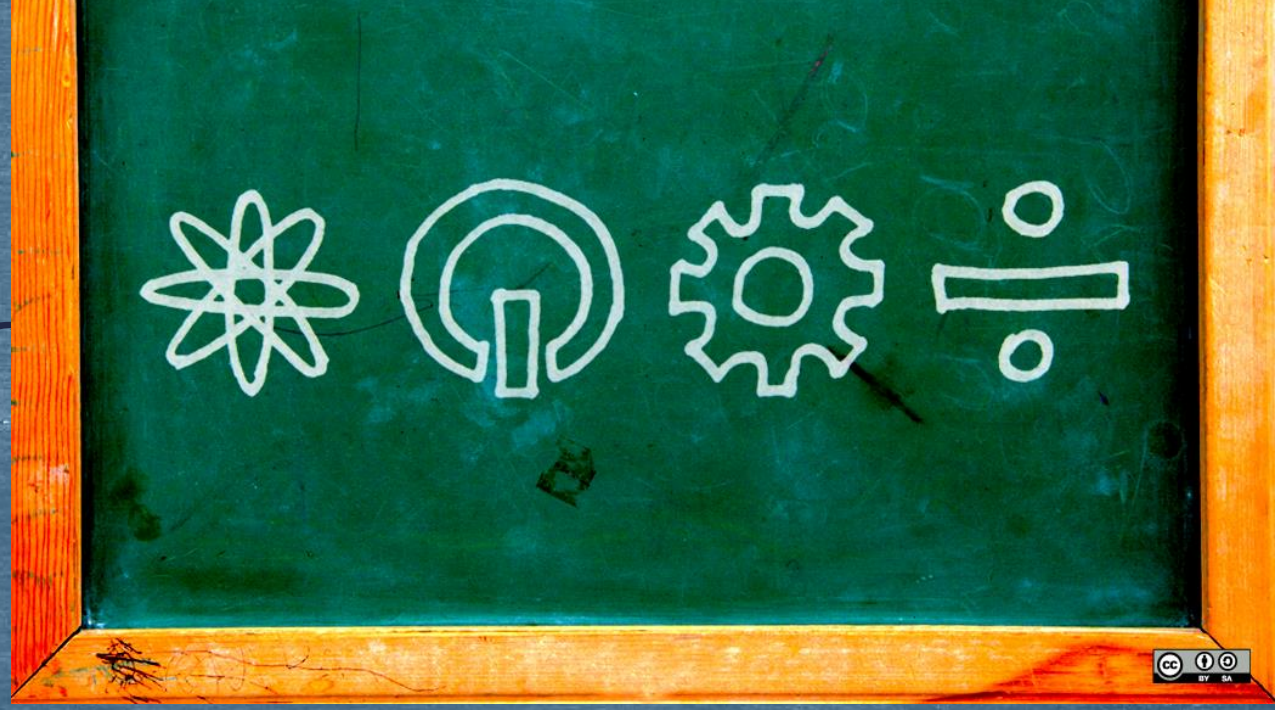
Increasing Interest and Engagement in Science with Small Unmanned Aerial Systems

Action Research in Project-Based Science, Technology, Engineering, and Mathematics (STEM) Education

Participant Survey

1. Agree or Disagree: sUAS have the potential to be valuable educational tools, even in elementary school.
   A. Agree
   B. Disagree
   C. Not Sure

Why Teach Integrated Science as a Part of STEM?



- Higher Interest
- More Relevant
- Project-Based, Hands-On
- Increased Efficiency
- Increased Effectiveness
- Inspiring
- Opportunities to Engage in Service Learning
- Opportunities to Involve the Community

Need/Rationale

- Students Uninterested, Underperforming.
- Lack of Relevance to Real-World Issues (Emphasis on Tests)
- Subjects Being Taught in Isolation; Lack of Understanding of how Subjects are Related and Complimentary
- Lack of Elementary STEM Programs (Curricular and Extracurricular)

Photo: Richard Rucker

Integrated Science, Technology, Engineering, and Mathematics (STEM) Education

- A National (and Global) Educational Priority
  - The President
  - United States Department of Education
  - National Science Foundation
- Industries are Crucial to Security and the Economy
- Stimulates Creativity and Innovative Thinking
- Engages Students in Complex Problem-Solving
- Allows for Collaborative, Project-Based Learning

Why sUAS?

- Small Unmanned Aerial Systems (sUAS or "Drones")
- Requested by Students
- Student-Centered
- High Interest
- Challenging
- Aligned with Philosophy and Goals

What Can sUAS Offer Education?

- **Science:** Force, Motion, Electromagnetism, etc.
- **Technology:** Electronics, Programming, Communications, etc.
- **Engineering:** Design Process, Planning, Prototyping, Testing, etc.
- **Math:** Measurement, Geometry, Algebra, Data Analysis, etc.
- **Also:** Problem-Solving, Teamwork, Interpersonal Communication, Time Management, Speaking/Presentation Skills, etc.

What Can sUAS Offer Education?

- High-Interest, Inspiring, Instills Confidence, Encourages Thinking about New Ways of Addressing Real-World Issues.
- Opens the door to additional, more advanced topics of study.

Development of the Instructional Unit

- Given the advanced levels of knowledge and skills needed to construct an sUAS, the instructional unit needed to be scaffolded.
- Six workshops were scheduled, each with a different activity.

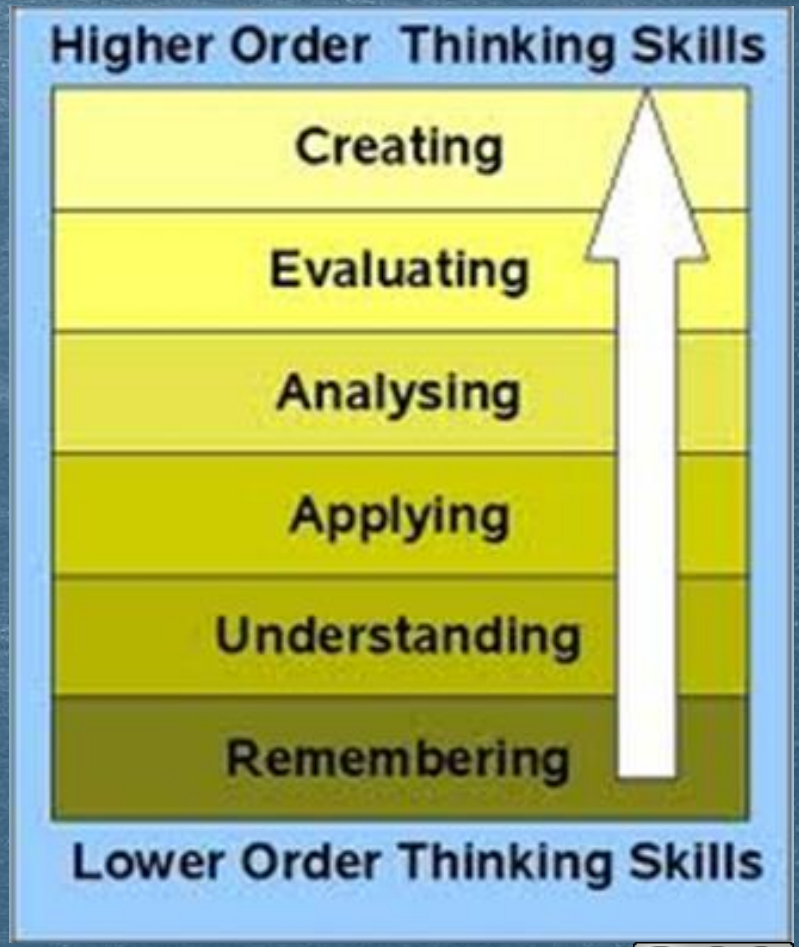


Photo: wikimedia.org

Model Rocketry

- Basic Construction Techniques
- Basic Principles of Flight
- Build Feelings of Satisfaction and Confidence

Photo: Mark Yap

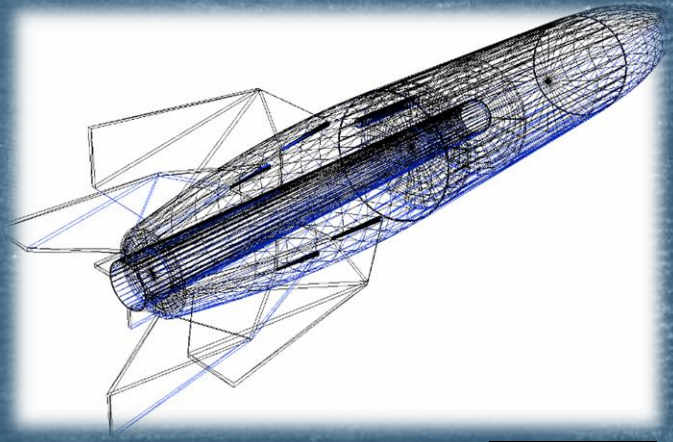


Photo: Steve Jurvetson

Underwater Remotely-Operated Vehicles (ROVs)

- Intermediate-Level Construction Techniques
- Use of Specialized Tools
- Integration of the Engineering Design Process
- Electrical Systems

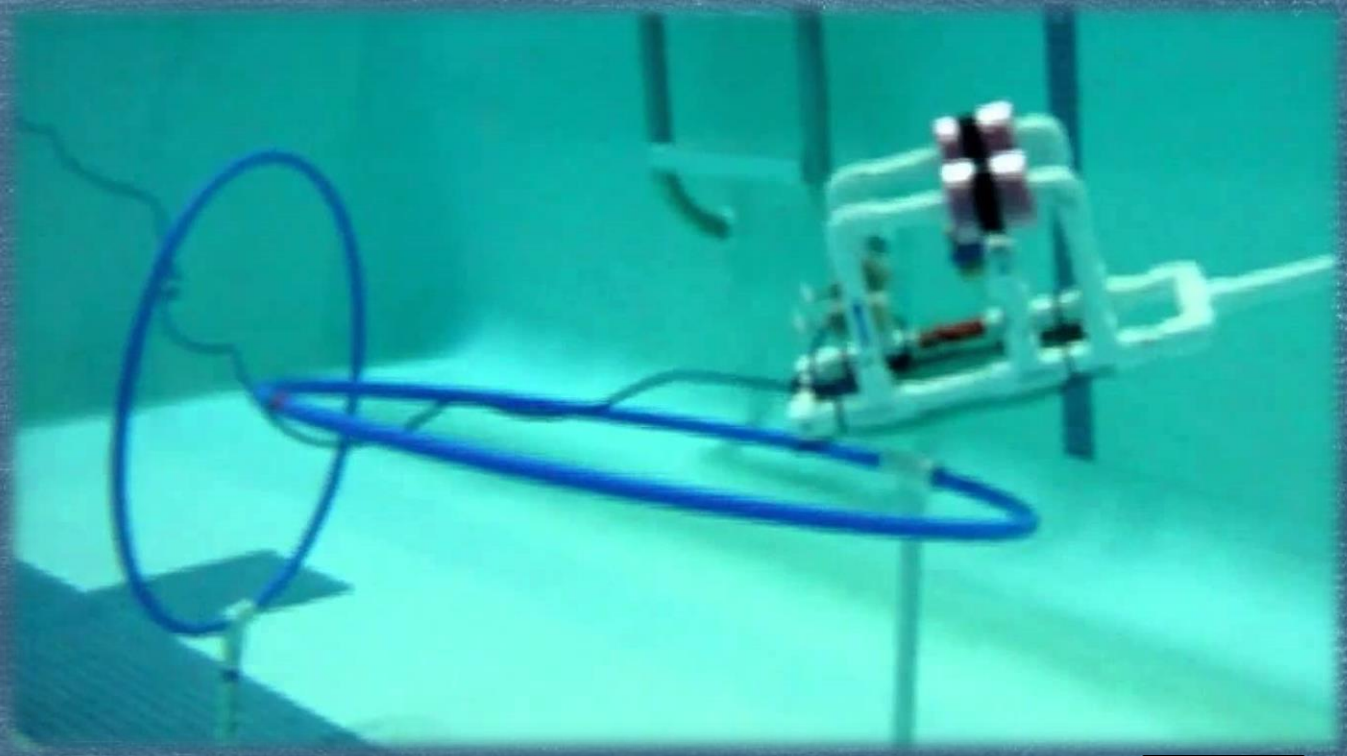


Photo: US Coast Guard

Basic Electronics

- Design: Circuits, Schematics, Calculations
- More Specialized Tools
- Introduction to Programming Hardware
- Practice with the Engineering Design Process
- Troubleshooting

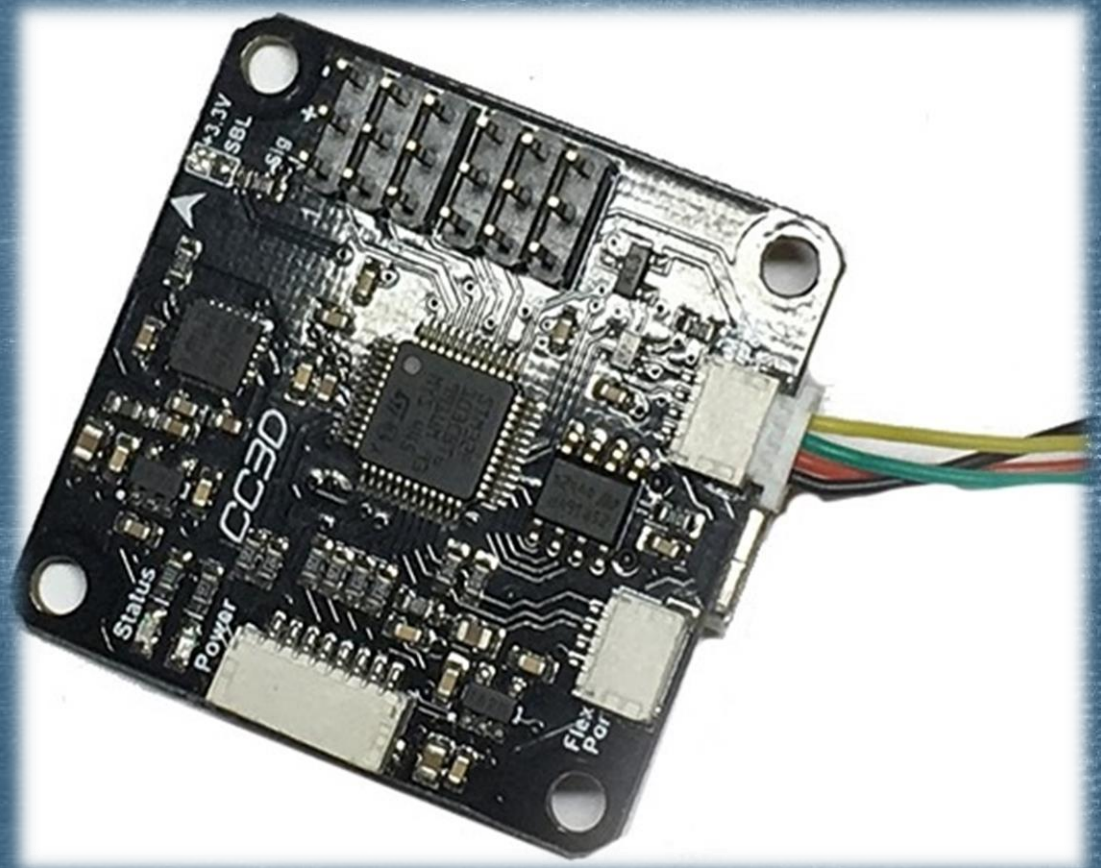


Photo: OpenPilot.org

Model Aircraft

- More Advanced Principles of Flight
- Electric Propulsions Systems
- Power Systems (Battery)
- Control Surfaces
- Remote Operation

Photo: Mark Yap

Communications Systems

- Electromagnetic Spectrum
- Radio Communication
- Communication Hardware

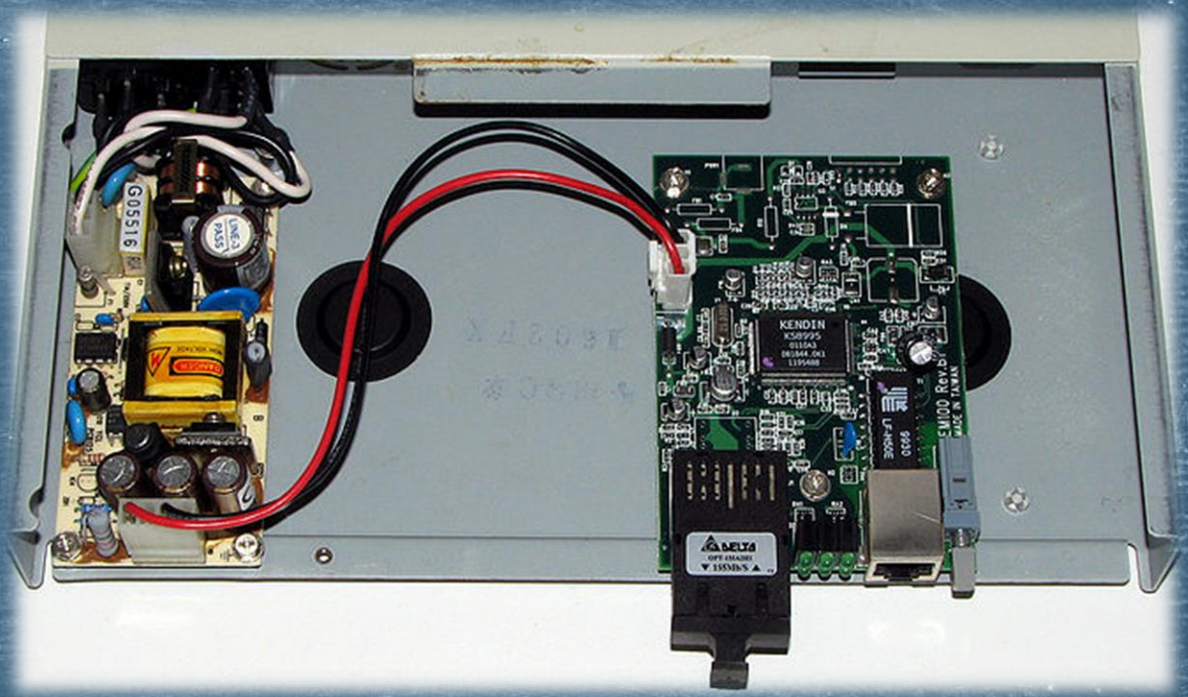
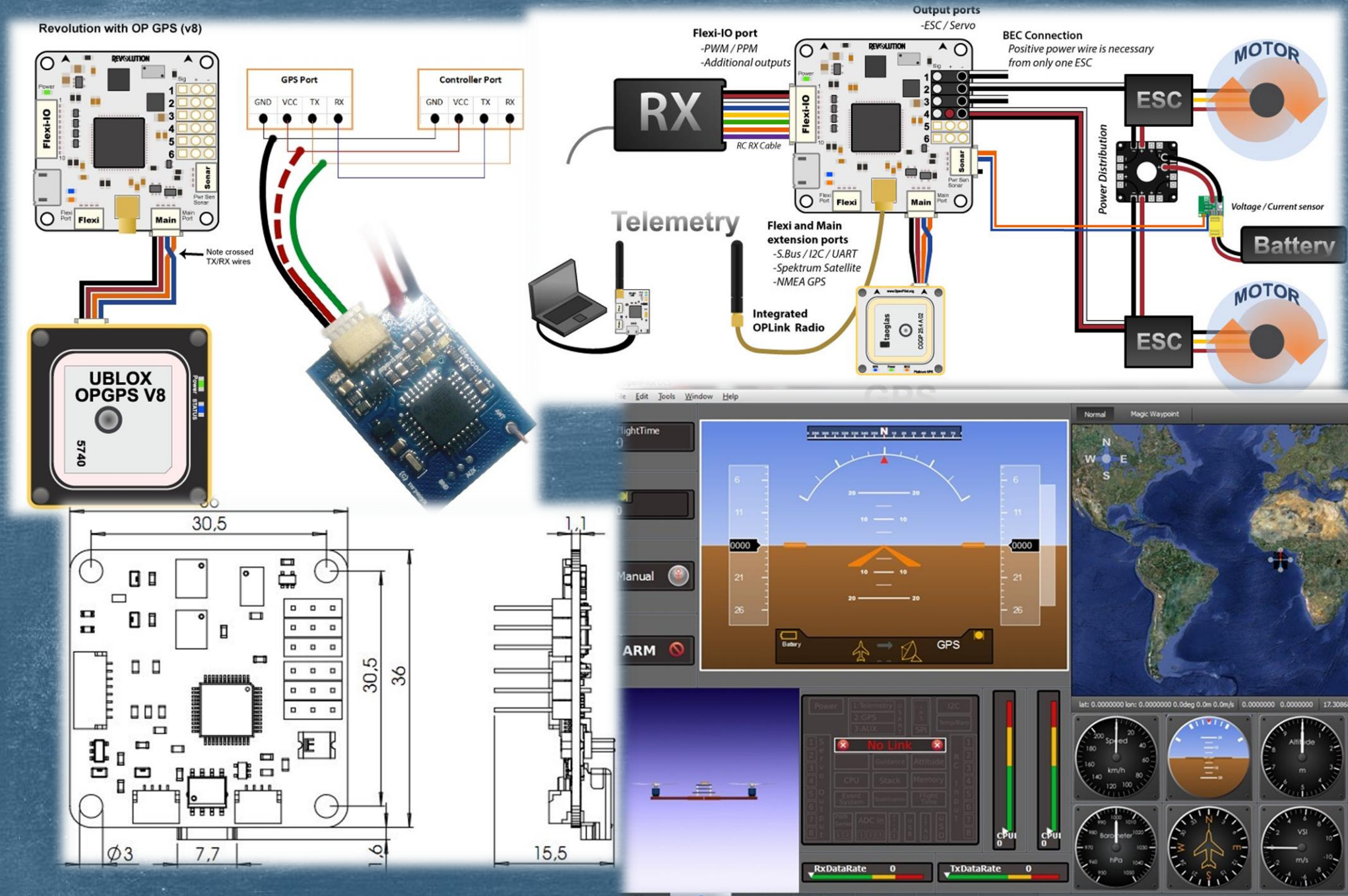


Photo: Adamantios

Small Unmanned Aerial Systems (sUAS)

- Designing and Planning
- Construction of Airframe
- Construction of Electrical System
- Programming of Flight Controller
- Transmitter Programming
- Transmitter/Receiver Setup
- Test Flights
- Revisions

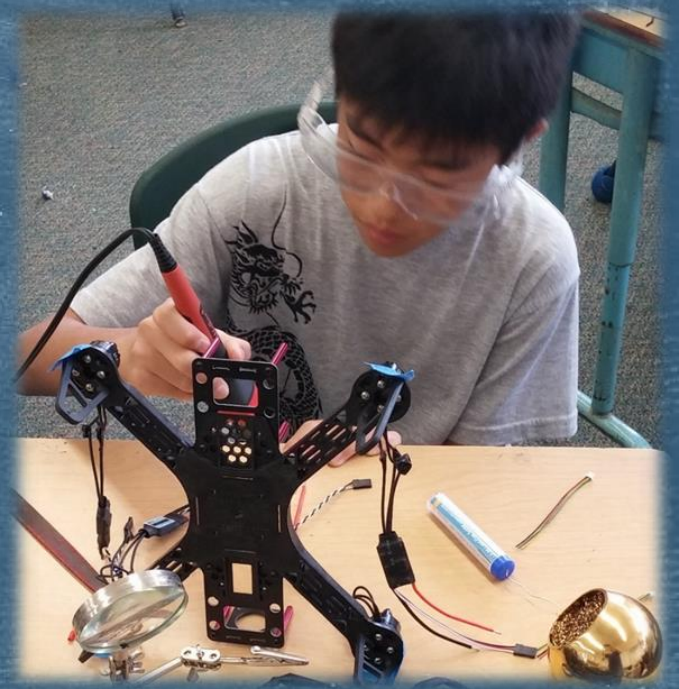

Revolution with OP GPS (v8)
REVOLUTION
Flexi-IO
Sonar
Flexi
Main
GPS Port
GND VCC TX RX
Controller Port
GND VCC TX RX
Note crossed TX/RX wires
UBLOX OPGPS V8
5740
Output ports
-ESC / Servo
Flexi-IO port
-PWM / PPM
-Additional outputs
RX
RC RX Cable
BEC Connection
Positive power wire is necessary from only one ESC
MOTOR
ESC
Power Distribution
Voltage / Current sensor
Battery
Telemetry
Flexi and Main extension ports
-S.Bus / I2C / UART
-Spektrum Satellite
-NMEA GPS
Integrated OPLink Radio
30,5
30,5
36
Ø3
7,7
1,6
1,1
15,5
Edit Tools Window Help
FlightTime
Manual
ARM
Battery
GPS
Normal
Magic Waypoint
No Link
RxDataRate 0
TxDataRate 0
Speed
km/h
Altitude
m
Barometer
hPa
VSI
m/s
Thro 0.00
Roll 0.00
Pitch 0.00
Yaw 0.00

Target Audience

- 10 Students
- Upper Elementary Grades
- Participants in an Extracurricular STEM Program
- Diverse Backgrounds and Interests

Workshop Schedule

- Workshop 1: Rockets and ROVs
- Workshop 2: Radio Communication Systems
- Workshop 3: Model Aircraft
- Workshop 4: sUAS Airframe and Electrical System Construction
- Workshop 5: Programming and Testing
- Workshop 6: Revisions and Testing



Action Research Purpose

The purpose of the action research project conducted was to evaluate the effectiveness of an instructional unit intended to increase overall level of interest and engagement in science of students in upper elementary school through project-based, STEM learning opportunities.

ARCS Model of Motivational Design (John Keller, 1983)

Attention	Relevance	Confidence	Satisfaction
Perceptual Arousal Provide novelty and surprise	***Goal Orientation*** Present objectives and useful purpose of instruction and specific methods for successful achievement	***Learning Requirements*** Inform students about learning and performance requirements and assessment criteria	***Intrinsic Reinforcement*** Encourage and support intrinsic enjoyment of the learning experience
Inquiry Arousal Stimulate curiosity by posing questions or problems to solve	***Motive Matching*** Match objectives to student needs and motives	***Successful Opportunities*** Provide challenging and meaningful opportunities for successful learning	***Extrinsic Rewards*** Provide positive reinforcement and motivational feedback
Variability Incorporate a range of methods and media to meet students' varying needs	***Familiarity*** Present content in ways that are understandable and that related to the learners' experiences and values	***Personal Responsibility*** Link learning success to students' personal effort and ability	***Equity*** Maintain consistent standards and consequences for success

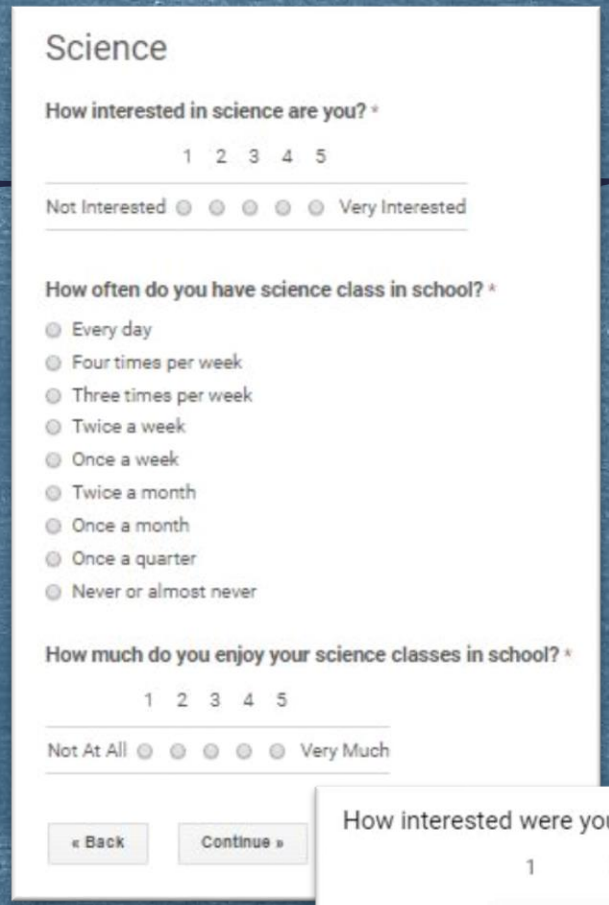
Research Questions

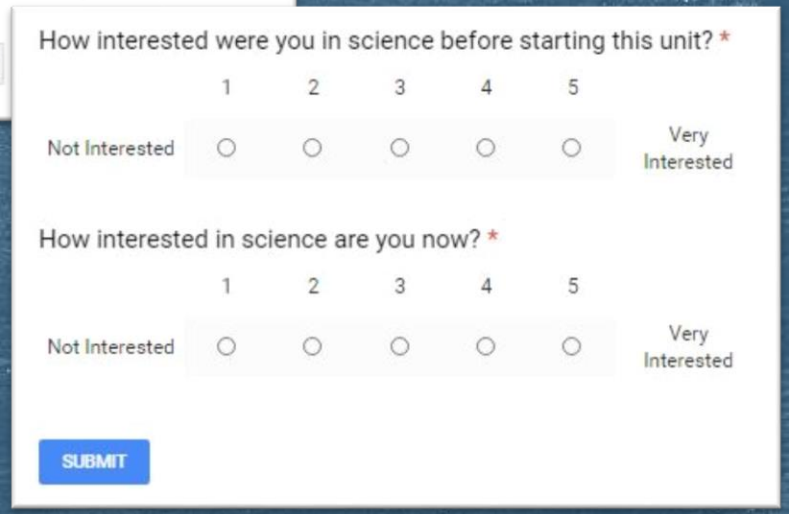
This action research project sought to answer two main questions:

1. What effect does the developed unit have on the four different aspects of the ARCS model (attention, relevance, confidence, and satisfaction)?
2. Does the instructional module result in an increased level of student engagement in science learning activities?

Instrumentation

- Pre-Assessment (Survey)
  - Students and Parents
  - Google Forms
- Interviews
  - Students and Parents
  - In-Person
- Retrospective Post-Assessment (Survey)
  - Students and Parents
  - Google Forms





Obstacles

- Lack of Time
- Glitches
- One Man Crew

Outcomes

- **Instructional Unit:** Achieved Goals
- **Scaffolding:** Worked Extremely Well
- **Action Research:** Effectively Showed Achievement of Goals
- **Students:** Excited, Want More
- **Parents:** Excited, Want More
- **Teachers:** Very Interested
- **Administration:** More Receptive
- **Community:** More Supportive
- **Me:** Very Rewarding, Fun

Lessons Learned

- More time is needed.
  - For Instruction
  - For the IRB process
- Recruit additional instructors/assistants and train them.
- Flexibility is key.
- Gain experience with all materials and tasks beforehand.
- Just because people say they will participate doesn't mean that they will.
- Give a window of time for responses (due dates)

Next Steps

- Revise the Instructional Unit
  - Implement over a greater period of time
- Expand the Instructional Unit
  - More in-depth exploration of each module
- Get More People Involved
- sUAS Activities
- Identify Areas of Further Research
  - Impact on Achievement
  - Long-Term Studies

Photo: Jon Super

Questions?